TITLE OF THE INVENTION

DRUM WASHING MACHINE

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of Korean Application No. 2003-50656, filed on July 23, 2003, in the Korean Intellectual Property Office, the disclosure of which is incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0002] The present invention relates to a drum washing machine and, more particularly, to a drum washing machine that uses less water, reduces an amount of electricity required to heat the water, and reduces washing time.

2. Description of the Related Art

[0003] In a conventional drum washing machine, a cylindrical rotary drum which is set in a drum-type water tub inside a cabinet, is rotated to repeatedly move upward laundry, seated on an internal surface of the rotary drum, along with water, thus causing the laundry and water to be dropped from a top to a bottom inside the rotary drum due to gravity, and thereby washing the laundry. An example of a conventional drum washing machine is disclosed in Japanese Patent Laid-open Publication No. 2001-149685. This conventional drum washing machine has a function of heating water to enhance the washing effect.

[0004] The conventional drum washing machine includes a water tub, a rotary drum, and a heater. The water tub contains water therein, while the rotary drum having a plurality of perforations around a sidewall thereof is rotatably set in the tub. The heater is installed at a predetermined position under the water tub so as to heat the water to a predetermined temperature. When the drum washing machine is operating and both water and detergent are fed into the water tub, the rotary drum is rotated in the tub at a low speed. During the washing operation of the washing machine, the heater heats the water to a predetermined temperature, thereby enhancing the washing effect of the washing machine.

[0005] However, the conventional drum washing machine may have several problems. That is, it is necessary to feed water into the washing machine to a level at which the laundry inside the rotary drum is sunk in the water which is also contained in a gap between the perforated rotary drum and the water tub. Therefore, the conventional drum washing machine must consume an excessive amount of water. Since the conventional drum washing machines are designed so that the water is fed into the water tub, and flows into the rotary drum through the perforations of the rotary drum until the laundry in the rotary drum is sunk in the water, a large amount of water must be fed into the water tub. Consumption of the water during the operation of the washing machine while in washing and rinsing operations is thus excessively increased, leading to an increase in cost.

[0006] Since the excessive amount of water is consumed during an operation of the conventional drum washing machine, the washing machine requires long periods of time for feeding or draining the water into or from the water tub. In addition, the time for which the conventional drum washing machine washes the laundry is further increased since the water must be heated to a predetermined temperature by the heater, before the rotary drum starts to be rotated to wash the laundry with the heated water. Furthermore, since the large amount of water must be heated to the predetermined temperature by the heater, the conventional drum washing machine excessively uses electricity to heat the water.

[0007] Another disadvantage in the conventional drum washing machine is that it is very difficult to produce the rotary drum, resulting in a complex production process of the washing machines, since the perforations must be formed around the sidewall of the rotary drum to allow the water to flow between the inside of the water tub and the rotary drum, and to allow the rotary drum to spin-dry the laundry during a spin-drying operation.

SUMMARY OF THE INVENTION

[0008] Accordingly, it is an aspect of the present invention to provide a drum washing machine, which uses less water, and reduces an amount of electricity required to heat the water, and reduces washing time, without reducing the washing effect of the drum washing machine.

[0009] It is another aspect of the present invention to provide a drum washing machine, which has a rotary drum designed to be easily produced.

[0010] Additional aspects and/or advantages of the invention will be set forth in part in the description which follows and, in part, will be obvious from the description, or may be learned by practice of the invention.

[0011] The foregoing and/or other aspects of the present invention are achieved by providing a drum washing machine comprising a water tub to contain water therein, and a rotary drum provided in the water tub wherein a rotating axis of the rotary drum is inclined relative to a horizontal axis at a predetermined first angle of inclination allowing an inlet opening of the rotary drum to be directed upward and forward, with a drain hole provided on the rotary drum at a position adjacent to the inlet opening, and an internal surface of the rotary drum being inclined relative to the rotating axis of the rotary drum at a predetermined second angle of inclination so as to guide the water to the drain hole, prior to discharging the water from the rotary drum to an outside of the rotary drum through the drain hole, a drive unit to drive the rotary drum, and a water circulation unit to feed the water from the water tub into the rotary drum.

[0012] The drum washing machine may further comprise a heater provided in a lower portion of the water tub so as to heat the water.

[0013] The drum washing machine may further comprise a drain unit having a drain pipe connected to the lower portion of the water tub and a drain pump mounted to an intermediate portion of the drain pipe.

[0014] The water circulation unit may comprise a control valve mounted to the drain pipe of the drain unit at a position around an outlet of the drain pump to control a flow direction of the water flowing from the drain pump, a water circulation pipe extending from the control valve to

the inlet opening of the rotary drum, and a spray nozzle mounted to an outlet of the water circulation pipe to spray the water into the rotary drum.

[0015] The rotary drum may comprise a rear part which is closed and coupled to a rotating shaft at a center of the rear part, a front part spaced apart from the rear part, with the inlet opening provided at a central portion of the front part, and the drain hole provided on an edge of the inlet opening of the front part, and a sidewall part which is closed and extends between the rear part and the front part wherein an inner diameter of the sidewall part increases along a direction from the rear part to the front part to allow an internal surface of the sidewall part to be inclined.

[0016] The drain hole may comprise a plurality of rows of drain holes which are provided around an edge of the front part of the rotary drum.

[0017] It is another aspect of the present invention to provide a drum washing machine wherein the rear part and the sidewall part of the rotary drum may be closed, and the drain hole may be provided on an edge of the sidewall part adjacent to the front part.

[0018] It is another aspect of the present invention to provide a drum washing machine wherein the sidewall part of the rotary drum may be connected to the front part along a junction which is rounded to provide a rounded junction surface, with the drain hole formed on the rounded junction surface.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] These and/or other aspects and advantages of the invention will become apparent and more readily appreciated from the following description of the embodiments taken in conjunction with the accompanying drawings of which:

FIG. 1 is a sectional view of a drum washing machine according to an embodiment of the present invention, when the washing machine is in a washing operation;

FIG. 2 is a sectional view of the drum washing machine of FIG. 1, when the washing machine is in a spin-drying operation;

FIG. 3 is a sectional view taken along a line of III-III' of FIG. 1;

FIG. 4 is a perspective view of a rotary drum included in the drum washing machine of FIG. 1;

FIG. 5 is a sectional view of the rotary drum of FIG. 4; and

FIGS. 6 and 7 are sectional views of a rotary drum, with drain holes provided on the rotary drum according to a first modification and a second modification of the embodiment of FIG. 1, respectively.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0020] Reference will now be made in detail to the embodiments of the present invention, examples of which are illustrated in the accompanying drawings, wherein like reference numerals refer to like elements throughout. The embodiments are described below to explain the present invention by referring to the figures.

[0021] As shown in FIG. 1, a drum washing machine according to the present invention includes a cabinet 10, a drum-type water tub 11, and a rotary drum 20. The drum-type water tub 11 is installed in the cabinet 10, and contains water therein. The rotary drum 20 is rotatably set in the water tub 11.

[0022] In the cabinet 10, the water tub 11 is installed to be inclined relative to a horizontal axis of the cabinet 10 at a predetermined first angle α of inclination, such that a front part 11a of the water tub 11 having an inlet opening 11b is placed at a position higher than a rear part 11c of the water tub 11. In the same manner as the water tub 11, the rotary drum 20 is installed in the water tub 11 such that a front part 22 of the rotary drum 20 having an inlet opening 23 is placed at a position higher than a rear part 21 of the rotary drum 20. That is, a rotating axis A of the rotary drum 20 is inclined relative to the horizontal axis of the cabinet 10 at the first angle α of inclination to allow the front part 22 having the inlet opening 23 to be placed at the position higher than the rear part 21. A rotating shaft 12, which is securely mounted to a center of the rear part 21 of the rotary drum 20, is rotatably held in a center of the rear part 11c of the water tub 11, thus allowing the rotary drum 20 to be rotated relative to the water tub 11. The water tub 11 is suspended in the cabinet 10 by a plurality of shock absorbing suspension units (not shown) while being apart from an internal surface of the cabinet 10.

[0023] A motor 13 that is a drive unit to rotate the rotating shaft 12 of the rotary drum 20 is installed at a position outside the rear part 11c of the water tub 11. The motor 13 includes a stator 13a which is mounted to the rear part 11c of the water tub 11, a rotor 13b which is

rotatably placed around the stator 13a, and a rotary disc 13c which couples the rotor 13b to the stator 13a.

[0024] The cabinet 10 has an inlet opening 14 at a front part thereof. The inlet opening 14 of the cabinet 10 is aligned with both the inlet opening 11b of the water tub 11 and the inlet opening 23 of the rotary drum 20, thus allowing a user to put laundry into the rotary drum 20 or take the laundry out of the rotary drum 20 through the three aligned inlet openings 14, 23 and 11b. A door 15 is mounted to an edge of the inlet opening 14 so as to close the opening 14. To prevent a leakage of the wash water from the water tub 11, a cylindrical bellows 16 extends between the inlet opening 14 of the cabinet 10 and the inlet opening 11b of the water tub 11. A cylindrical guide unit 17 is placed inside the bellows 16 to allow the user, who stands outside the inlet opening 14 of the cabinet 10, to easily put the laundry into the rotary drum 20 or take the laundry out of the rotary drum 20.

[0025] A detergent supply unit 18 and a water supply unit 30 are installed in the cabinet 10 at positions above the water tub 11 to respectively feed each of a detergent and water into the water tub 11. The detergent supply unit 18 is placed at the front part of the cabinet to allow the user to easily feed the detergent into the water tub 11. The water supply unit 30 comprises a first water feed pipe 32 which extends from an external water supply pipe 31 to the detergent supply unit 18, a second water feed pipe 33 which extends from the detergent supply unit 18 to the water tub 11, and a first control valve 34 which is mounted to an intermediate portion of the first water feed pipe 32 to control a flow of the water to be fed into the water tub 11. Due to the coupled construction of the detergent supply unit 18 and the water supply unit 30, the water passes through the detergent supply unit 18, prior to reaching the water tub 11. Therefore, the detergent contained in the detergent supply unit 18 is fed into the water tub 11 in a state dissolved in the water.

[0026] The drum washing machine has a heater 40 that is placed in a lower portion of the water tub 11 so as to heat the water contained in the water tub 11. A heater holding part 41, which is a pan-shaped part, is provided at a lower portion of a sidewall of the water tub 11 by drawing the lower portion of the sidewall of the tub 11 downward, as shown in FIGS. 1, 2 and 3. The heater 40 is installed in the heater holding part 41 in which a predetermined amount of water is collected to a level to allow the heater 40 to be submerged into the water. Since the

heater 40 is placed in the heater holding part 41 having a pan-shaped appearance, the rotary drum 20 is rotated without interfering with the heater 40.

[0027] The drum washing machine also has a drain unit 50 and a water circulation unit 60. The drain unit 50 discharges the water from the water tub 11 to an outside of the tub 11. The water circulation unit 60 feeds the water, which is heated by the heater 40 in the water tub 11, into the rotary drum 20. The drain unit 50 comprises a first drain pipe 51, a drain pump 52, and a second drain pipe 53. The first drain pipe 51 is connected to a drain port 42 which is provided at the heater holding part 41 of the lower portion of the water tub 11, thus discharging the water from the water tub 11 to the outside of the tub 11. The drain pump 52 is mounted to an intermediate portion of the first drain pipe 51. The second drain pipe 53 extends from an outlet of the drain pump 52. The water circulation unit 60 includes a second control valve 61, a water circulation pipe 62, and a spray nozzle 63. The second control valve 61 is mounted to an intermediate portion of the second drain pipe 53 that extends from the outlet of the drain pump 52. The water circulation pipe 62 extends from the second control valve 61 to the inlet opening 23 of the rotary drum 20. The spray nozzle 63 is mounted to an outlet of the water circulation pipe 62. The second control valve 61 controls a flow direction of the wash water flowing from the outlet of the drain pump 52 so as to drain the discharged wash water to an outside of the cabinet 10 or to guide the discharged wash water into the water circulation pipe 62. A motorized three-way valve may be used as the second control valve 61. The spray nozzle 63 is held by the guide unit 17 which is placed adjacent to the inlet opening 23 of the rotary drum 20, thus spraying the wash water into the rotary drum 20 through the inlet opening 23. Due to the above-described coupled construction of the drain unit 50 and the water circulation unit 60, the water which is discharged from the lower portion of the water tub 11 may be drained to the outside of the cabinet 10 or be sprayed into the rotary drum 20. That is, when the drain pump 52 is operated with the second control valve 61 controlled to guide the discharged water to the water circulation pipe 62, as shown in FIG. 1, the discharged water passes through both the first drain pipe 51 and the water circulation pipe 62 to be sprayed into the rotary drum 20. However, when the drain pump 52 is operated with the second control valve 61 controlled to guide the discharged water to the second drain pipe 53, as shown in FIG. 2, the discharged water is drained to the outside of the cabinet 10.

[0028] As shown in FIGS. 4 and 5, the rotary drum 20, which is installed in the water tub 11 to be inclined relative to the horizontal axis of the cabinet 10 at the first angle α of inclination,

comprises the front part 22 having the inlet opening 23, the rear part 21 securely coupled to the rotating shaft 12, and a cylindrical sidewall part 24 extending between the front part 22 and the rear part 21. The rotary drum 20 is completely closed along a junction between the rear part 21 and the cylindrical sidewall part 24 so as to contain the water in the drum 20. An inner diameter of the cylindrical sidewall part 24 of the rotary drum 20 gradually increases along a direction from the rear part 21 to the front part 22, thus allowing an internal surface of the cylindrical sidewall part 24 of the rotary drum 20 to be inclined relative to the rotating axis A of the rotary drum 20 at a predetermined second angle β of inclination. A plurality of drain holes 25 are provided along an edge of the inlet opening 23 of the front part 22 to discharge the water from the rotary drum 20 to an outside of the rotary drum 20 through the drain holes 25 when the rotary drum 20 is rotated at a high speed. As shown in FIG. 3, the rotary drum 20 also has a plurality of lifters 26 around an internal surface of the cylindrical sidewall part 24, thus repeatedly moving the laundry upward along with the water to drop the laundry and wash water from the top to the bottom inside the rotary drum 20 due to gravity, when the rotary drum 20 is rotated in the water tub 11. To enhance the washing effect of the drum washing machine, a plurality of agitating blades 27 are provided on an internal surface of the rear part 21 of the rotary drum 20.

[0029] Since the rotary drum 20 is installed such that the rotating axis A of the rotary drum 20 is inclined relative to the horizontal axis of the cabinet 10 at the first angle α of inclination, a predetermined amount of water is contained in the rotary drum 20 to allow the laundry to be sunk into the water. The water is fed into the rotary drum 20 to reach a level that is not higher than a lowermost drain hole 25 of the rotary drum 20. The first angle α of inclination of the rotating axis A of the rotary drum 20 relative to the horizontal axis of the cabinet 10 may be set to approximately 15° in order to contain an appropriate amount of water in the rotary drum 20 and effectively wash the laundry.

[0030] As described above, the internal surface of the rotary drum 20 is inclined relative to the rotating axis A of the rotary drum 20 at the second angle β of inclination, and the drain holes 25 are provided along the edge of the inlet opening 23 of the front part 22 of the rotary drum 20. As a result, the water is guided to the drain holes 25 of the rotary drum 20 during a rotation of the rotary drum 20. That is, when the rotary drum 20 is rotated at a high speed during a spin-drying operation of the washing machine, the water is squeezed out of the laundry in the rotary

drum 20 to move outward in a radial direction of the rotary drum 20 due to a centrifugal force, and is guided to the drain holes 25 provided on the front part 22 of the rotary drum 20 along the inclined internal surface of the cylindrical sidewall part 24, prior to being discharged to the outside of the rotary drum 20. To allow a smooth discharging of the water from the rotary drum, the second angle β of inclination of the internal surface of the rotary drum 20 relative to the rotating axis A of the rotary drum 20 may be set at 0.5° or higher.

[0031] FIGS. 6 and 7 are sectional views of a rotary drum 20, with drain holes provided on the rotary drum 20 according to a first modification and a second modification of the embodiment of FIG. 1, respectively. In the first modification of FIG. 6, a plurality of rows of drain holes 25a are provided on the front part 22 of the rotary drum 20 along the edge of the inlet opening 23 and drain holes 25b are provided around an edge of the cylindrical sidewall part 24 adjacent to the front part 22. Due to the drain holes 25a and 25b, the rotary drum 20 of FIG. 6 more effectively discharges the water to the outside thereof, in comparison with the rotary drum 20 of FIG. 4.

[0032] In the second modification of FIG. 7, the rotary drum 20 is rounded along a junction corner 28 between the front part 22 and the cylindrical sidewall part 24, with a plurality of drain holes 25c being formed along the rounded junction corner 28. The rotary drum 20 of FIG. 7 may be reduced in a water draining effect thereof, in comparison with the rotary drum 20 of FIG. 6. However, the rotary drum 20 of FIG. 7 may desirably contain a large amount of water therein, without enlarging the angle α of inclination of the rotary drum 20 relative to the horizontal axis of the cabinet 10.

[0033] The drum washing machine having the above-mentioned construction is operated as follows.

[0034] To execute a washing operation, the washing machine is turned on after laundry is put into the rotary drum 20 and a detergent is contained in the detergent supply unit 18. When the washing machine is turned on as described above, the first control valve 34 of the water supply unit 30 is opened to feed water into the water tub 11. When the water is fed into the water tub 11, the water passes through the detergent supply unit 18 prior to reaching the water tub 11, due to the coupling of the detergent supply unit 18 and the water supply unit 30. Therefore, the detergent contained in the detergent supply unit 18 is fed into the water tub 11 while being

dissolved in the water. After a predetermined amount of water is fed into the water tub 11, the supply of water into the water tub 11 is stopped. Since both the rear part 21 and the cylindrical sidewall part 24 of the rotary drum 20 as well as the junction between the rear part 21 and the sidewall part 24 are completely closed, the water is not introduced into the rotary drum 20 during the supply of the water into the water tub 11, but the water is contained in the heater holding part 41 provided at the lower portion of the sidewall of the water tub 11. In addition, since it is not necessary to feed the water into the water tub 11 to a level allowing the laundry in the rotary drum 20 to be submerged into the water, as in the conventional drum washing machine, the amount of water required to wash the laundry is substantially reduced.

[0035] When the predetermined amount of water is completely fed into the water tub 11, the heater 40 is turned on to heat the water. Since the amount of water contained in the water tub 11 is reduced, in comparison to the conventional drum washing machine, as described above, it is possible to quickly heat the water within a short period, thereby shortening the washing time and reducing an amount of electricity required to heat the water.

[0036] After the water in the water tub 11 is completely heated by the heater 40 to a predetermined temperature, the control valve 61 of the water circulation unit 60 is operated to permit the outlet of the drain pump 52 to communicate with the water circulation pipe 62. When the drain pump 52 in the above state is operated, the heated water is discharged from the heater holding part 41 to pass through both the first drain pipe 51 and the water circulation pipe 62, thus being fed into the rotary drum 20. In the above state, an entire part of the laundry contained in the rotary drum 20 is uniformly wet with the water since the spray nozzle 63 sprays the water onto the laundry. The rotary drum 20 is rotated at a low speed by the motor 13 simultaneously with the spraying of the water into the rotary drum 20, thus washing the laundry.

[0037] During the washing operation, the entire laundry contained in the rotary drum 20 is sufficiently wet with the water that is contained in the rotary drum 20 since the rotary drum 20 is installed in the cabinet 10 to be inclined relative to the horizontal axis of the cabinet 10 at the first angle α of inclination, as shown in FIG. 1. The drum washing machine thus smoothly and effectively executes the washing operation. When the level of the water in the rotary drum 20 exceeds the height of a lowermost drain hole 25 of the rotary drum 20 during the washing operation, the water overflows from the rotary drum 20 into the water tub 11 through the drain holes 25, prior to returning from the water tub 11 to the rotary drum 20 by an operation of the

drain pump 52. The circulation of the water is continued during the washing operation. When the drum washing machine performs in the washing operation, most of the water is continuously fed from the water tub 11 into the rotary drum 20, so that the water tub 11 contains only a small amount of water therein.

[0038] When the washing operation is finished, the drum washing machine executes a rinsing operation to repeatedly rinse and spin-dry the washed laundry. To execute the rinsing operation, the washed laundry must be primarily spin-dried. To spin-dry the washed laundry, the drain pump 52 is operated with the second control valve 61 controlled to permit the outlet of the drain pump 52 to communicate with the second drain pipe 53, and the rotary drum 20 is rotated at a high speed, thus spin-drying the washed laundry. While the rotary drum 20 is rotated at a high speed to spin-dry the laundry, the water is primarily squeezed out of the laundry in the rotary drum 20 to move radially outward to the internal surface of the cylindrical sidewall part 24 of the rotary drum 20 due to a centrifugal force, and is secondarily guided to the drain holes 25 provided on the front part 22 of the rotary drum 20, since the internal surface of the rotary drum 20 is inclined relative to the rotating axis A of the rotary drum 20 at the second angle β of inclination, as shown in FIG. 2. The water in the rotary drum 20 is thus discharged to the outside of the rotary drum 20 through the drain holes 25, and the water in the water tub 11 is drained to the outside of the cabinet 10 by the operation of the drain pump 52. After spin-drying the washed laundry, new water enters the water tub 11 by the operation of the water supply unit 30, and is introduced into the rotary drum 20 by the operation of the water circulation unit 60, in the same manner as that described for the washing operation, thus rinsing the laundry. During the rinsing operation, the spin-drying of the laundry and the feeding of new water into the water tub 11 are repeated several times.

[0039] The rinsing operation is ended with a final spin-drying of the rinsed laundry. To finally spin-dry the rinsed laundry, the drain pump 52 is operated with the second control valve 61 controlled to permit the outlet of the drain pump 52 to communicate with the second drain pipe 53, and the rotary drum 20 is rotated at high speeds for a predetermined period of time. That is, the final spin-drying of the rinsed laundry is performed in the same manner as an intermediate spin-drying of the laundry during the rinsing operation.

[0040] The present invention provides a drum washing machine in which a rotary drum is installed in a cabinet to be inclined relative to a horizontal axis of the cabinet, and both a rear

part and a sidewall part of the rotary drum as well as a junction between the rear part and the sidewall part are completely closed. Water is contained in the rotary drum during a washing operation of the drum washing machine. Therefore, the drum washing machine uses less water to wash laundry, without reducing the washing effect as in the conventional drum washing machines.

[0041] In addition, the drum washing machine feeds a small amount of water from a water tub into the rotary drum after heating the small amount of water by use of a heater, thus reducing an amount of electricity required to heat the water, and reducing the washing time. Since the drum washing machine uses less water to wash laundry, the washing machine quickly feeds and drains the water into and from the water tub, thus reducing the overall washing time.

[0042] Since the drum washing machine washes the laundry by use of the less water as described above, the washing machine drains less water, thus reducing the amount of wastewater causing environmental pollution.

[0043] Furthermore, the rotary drum of the drum washing machine does not have spin-drying perforations on the rear part or the sidewall part thereof, therefore resulting in a simple construction thereof.

[0044] Although a few embodiments of the present invention have been shown and described, it would be appreciated by those skilled in the art that changes may be made in these embodiments without departing from the principles and spirit of the invention, the scope of which is defined in the claims and their equivalents.